Earth Science Serving Society: Observations, Health, and Air Quality

GEO User Interface Committee
UIC Meeting: Health Break-out Group
August 1-3, 2007

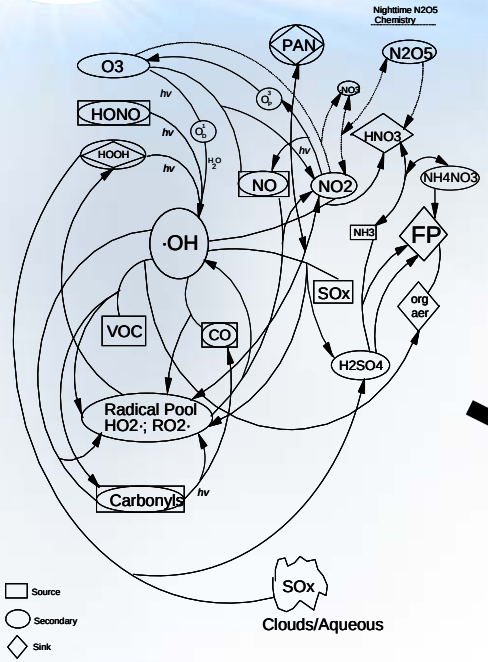
Lawrence Friedl & John Haynes
Program Managers
Applied Sciences Program
NASA Earth Science Division

Air Quality & Public Health

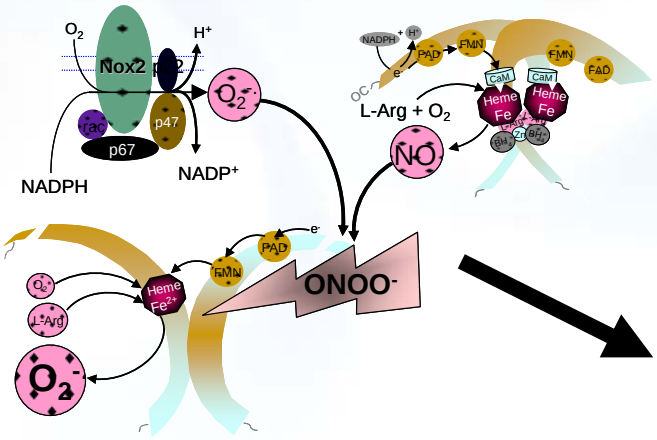
Environmental public health tracking:

Hazards, Exposure, Health Effects

Epidemiology, Forecasting, Public Warning



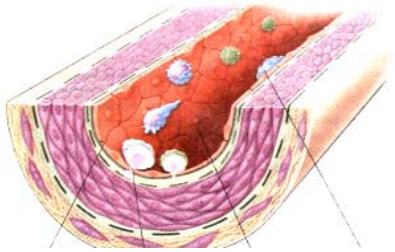
Atmospheric Pathways



Source, Harrison, 2006

Reactive Oxidant Cell Chemistry Processes

Source, Harrison, 2006

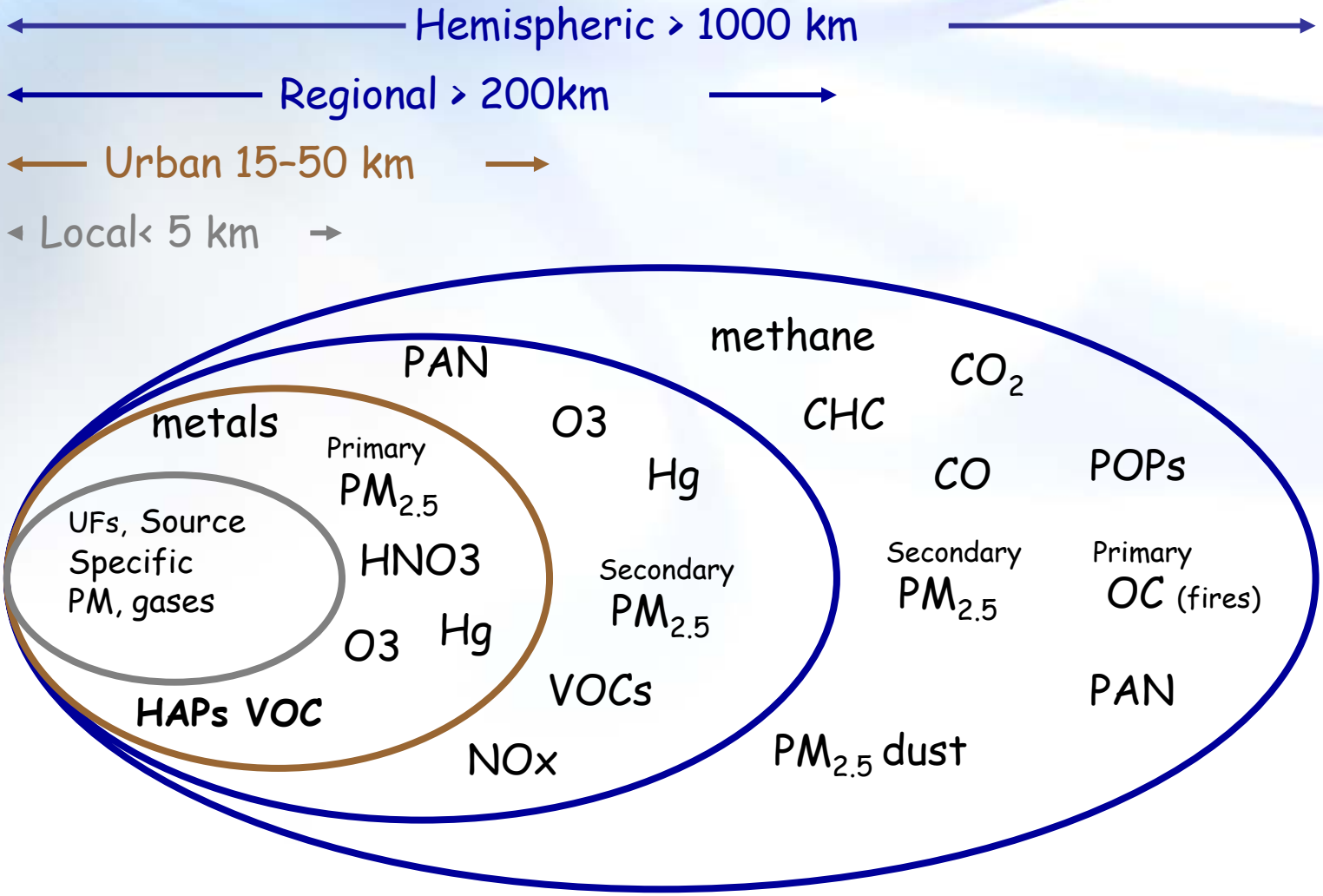


Hypothesized effect

Symmetries in atmospheric and cellular level chemistries

R.Scheffe, US EPA

Air Quality & Public Health



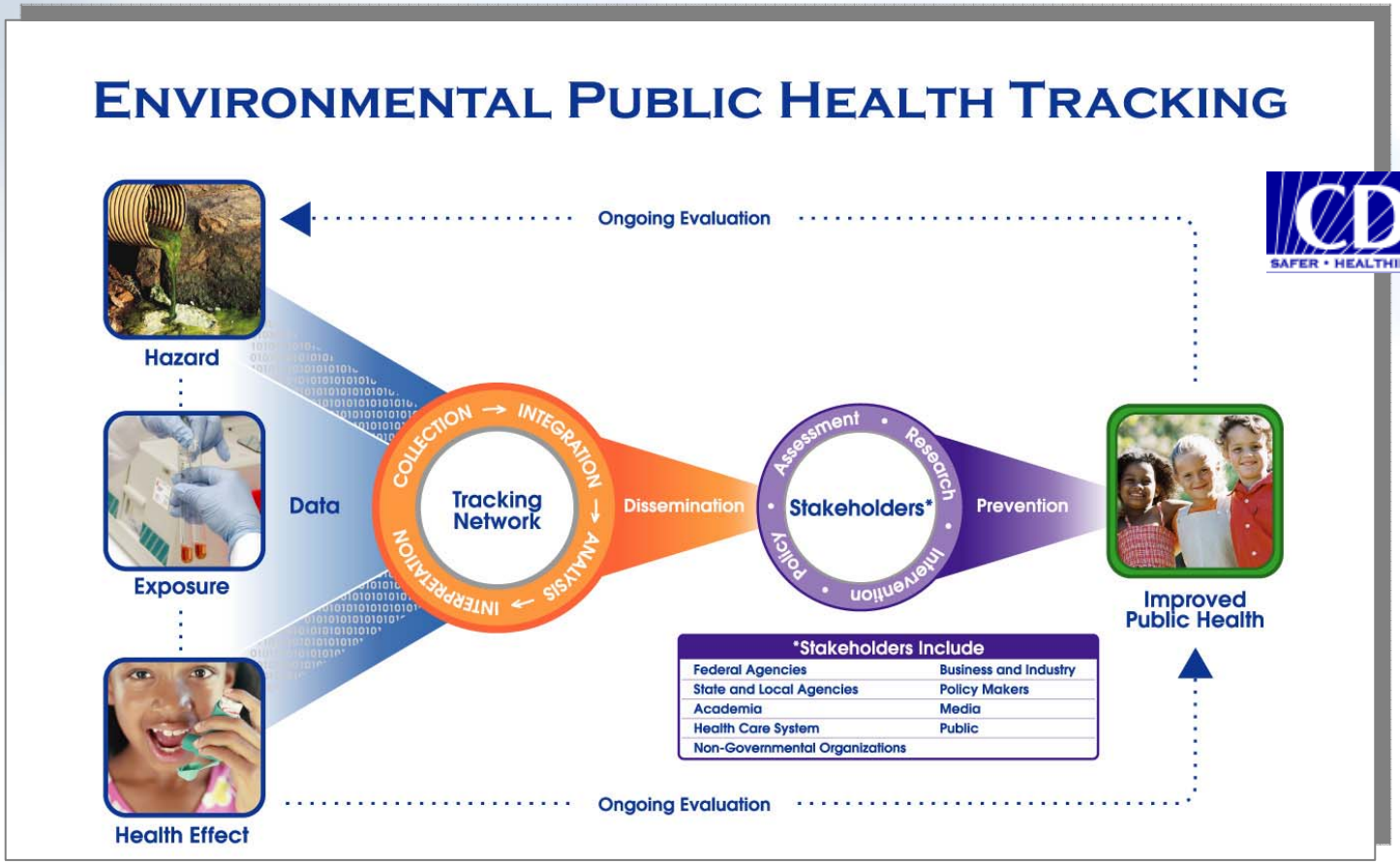
R.Scheffe, US EPA

Air Quality & Public Health

Workshop & Attendees

Applications of Environmental Remote Sensing
to Air Quality and Public Health

May 8-9, 2007 in Maryland, USA



Air Quality & Public Health

Workshop & Attendees

Applications of Environmental Remote Sensing
to Air Quality and Public Health

May 8-9, 2007 in Maryland, USA

The workshop's objectives were to further collaborations among atmospheric and Earth scientists and Public Health researchers in the field of environmental health research and applications:

- *Provide an overview of projects in the areas of Air Quality and Public Health that have cross-disciplinary relevance*
- *Identify data needs of Air Quality and Public Health research and management communities*
- *Develop partnerships and identify collaborative research and applications opportunities*

Air Quality & Public Health

Workshop & Attendees

Applications of Environmental Remote Sensing
to Air Quality and Public Health

May 8-9, 2007 in Maryland, USA

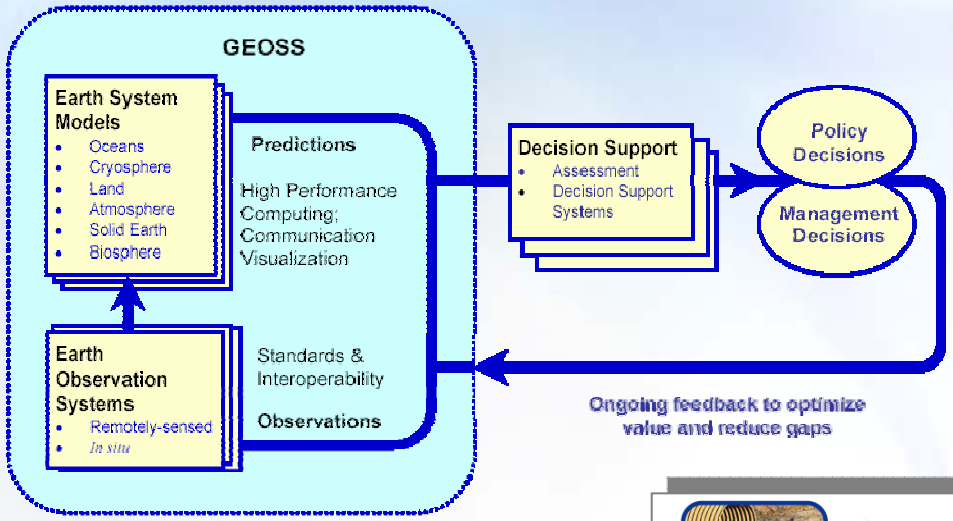
Conference attendees spanned the sectors of government, academia, private, and research institutes.

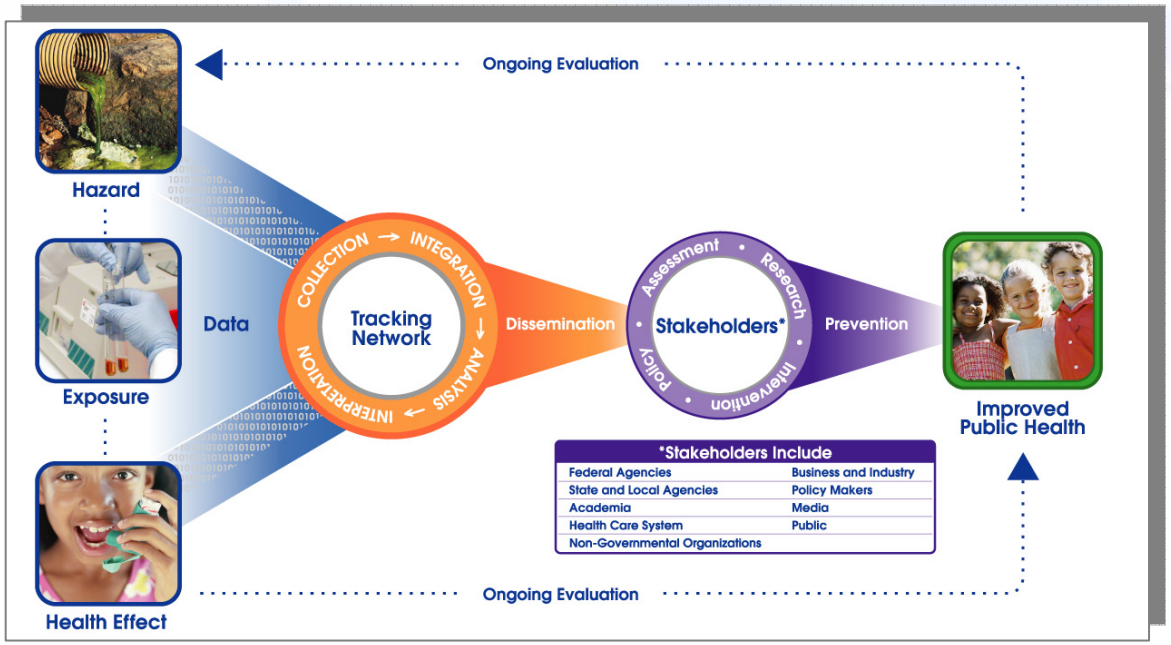
Total Attendance:	74
Government (US Fed, state, local):	*44*
Academia:	*22*
Private/NGOs:	*8*

http://weather.msfc.nasa.gov/conference/healthconference_home.html

Earth Observations & Air Quality

Integrated Solutions & Decision Support





Spatial approaches to epidemiology & public health

Determinants of exposure

From presentation by Dr Linda Beale
Research Associate, Small Area Health Statistics Unit (SAHSU), UK

- Hazard intensity
  - Spatial distribution
  - Temporal variability
  - Micro-environment
- Population distribution
  - Population pattern
  - Time-activity
- Behaviour
  - Consumption
  - Activity level
  - Lifestyle
- Physiography
  - Stature
  - Age
  - Gender

Exposure occurs as people move through, and reside within, a changing hazard field

How can we assess exposures?

From presentation by Dr Linda Beale Research Associate, Small Area Health Statistics Unit (SAHSU), UK

- Direct methods
  - Bio-monitoring
  - Personal exposure
  - Self-reporting
- Indirect methods
  - Natural recorders
  - Exposure proxies
  - Spatial modelling
  - Process modelling

Typically environmental exposure assessment is based on the use of routine monitoring sites

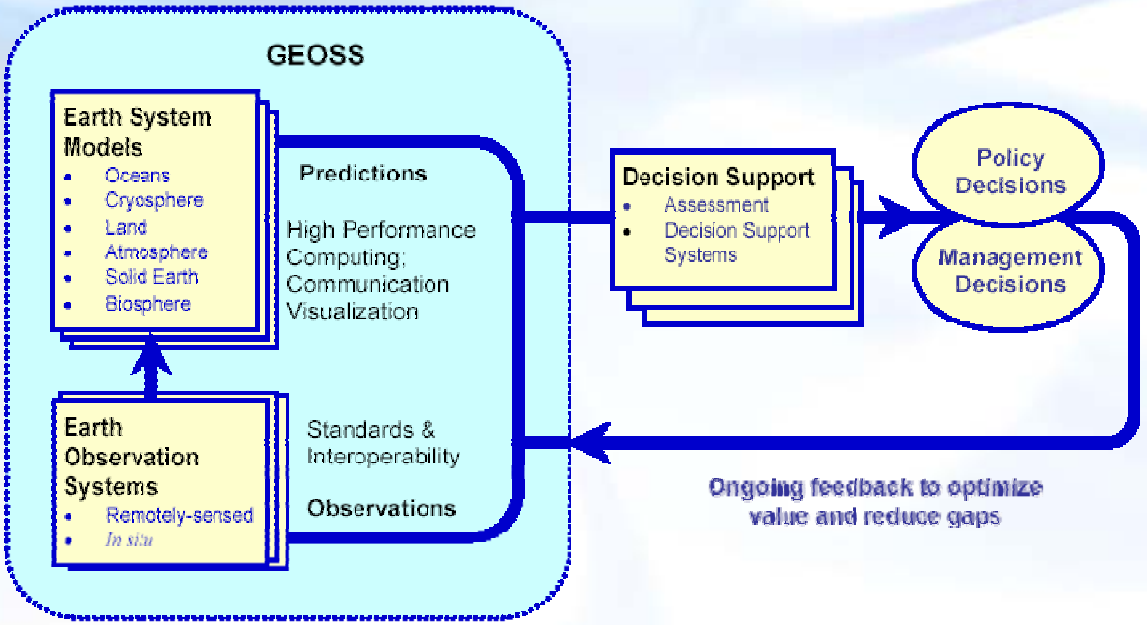
Sources of data for exposure modelling

From presentation by Dr Linda Beale
Research Associate, Small Area Health Statistics Unit (SAHSU), UK

- Environmental surveys
  - Soils, geology etc
- Ground-based monitoring
  - Routine monitoring networks
  - Purpose-designed surveys
  - Natural monitors
- Earth observation
  - Satellites
  - Airborne monitors
- Census data
  - Population censuses

Earth Observations

Air Quality & Public Health



For Public Health discussions, we need to approach the discussion as:

What additional or augmented studies/projects can the Public Health community do with the existing/upcoming Earth observations?

rather than

Can satellites provide/replace the data the PH community currently uses?

Workshop Findings *(Selected)*

Particulate Matter

State of Practice

- 10 km AOD product exists from MODIS
- 5 km & 1 km products in development
- Accuracies (10-15%) have been driven by the climate community
- Particle size over land (in 1-3 yrs)
- AOD is not in µg/m3
- Need to assess gradients in 10 km product
- User community: Better temporal resolution may be more important than finer spatial resolution.
- There's research into the vertical distribution and concentration
- Have to infer the Boundary Layer

Findings & Opportunities

The current strength of the AOD product is it's "context"
– used qualitatively (semi-quantitative)
– how extensive is an event
– the spatial/temporal intensity of an event

Need to assess accuracies for Public Health (especially with AQI error bars)

Ideal PM measurements:
– 1-km or better resolution
– Vertical profiles
– Some speciation
– 1-2 times/day

Workshop Findings *(Selected)*
Epidemiology

Issues

What are acceptable error estimates for various public health applications?

Need for connections between Earth observation & Epidemiology communities:

- Need to 'practice' together
- Epidemiologists need help to identify what they should ask about remote sensing and Earth observations
- Error estimates are large in some cases & epidemiologists should ask about them
- Earth observations community needs a better sense of how epidemiologists make their assessments
- A major research interest is the question 'are some PM more toxic than others'

Findings & Opportunities

There's a need for a forum to discuss how the public health community does exposure assessment

Earth observation community need to attend Public Health & epidemiology conferences to better understand issues and learn "what they do"

Need for "Remote Sensing 101" and "Epidemiology 101" training to help facilitate communication between communities.

Research to better estimate exposure and uncertainties

Workshop Findings *(Selected)*

Highest Priority Pollutants to address: PM and ozone

Need to address quantifying the accuracy of environmental conditions.
For models, a factor of 2 error in PM estimates may be acceptable for climate research, but will that satisfy public health needs?

Communities should think of *collaboration with partners* who have access to PH data -- rather than trying to get direct access to PH data

Need to address issue of error propagation in model forecasts (uncertainty)

Workshop Findings *(Selected)*

Needed:

- Peer reviewed publications that show that integrating the remotely sensed data do have positive contribution to the health studies
- Proof of concept that remotely sensed data enhance the exposure estimates compared to the AQ system monitoring only case
- Study of linkage and correlation between environmental parameters enhanced by utilizing remotely sensed data sets and simple health data like mortality or cardiovascular mortality
- What air pollution epidemiology needs from the satellite data
- Burden of disease studies, especially for developing countries
- Opportunity to evaluate how health community does exposure assessment and related issues

Air Quality & Public Health Workshop

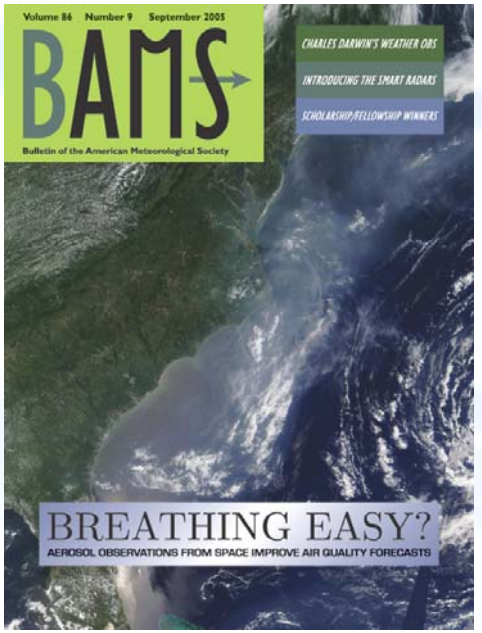
Near-term Opportunities

- Formation of a "Working Group" to link RS community to the user community and the epidemiology community (group may be used to inform future mission requirements).
- Outreach to upcoming exposure/epidemiology conferences (*e.g.,* Symposium planned at the American Society of Tropical Medicine and Hygiene Conference in November).
- Planned Visualization Workshop (approaches to displaying qualitative info)
- Use of "Wiki" by the Air Quality & Public Health community (using ESIP Federation site).
- Outreach - Need people to attend:
  - International Society of Environmental Epidemiology
  - International Society of Environmental Exposure Conference
  - American Association of Aerosol Research (AAAR)
  - Health Effect Institute (HEI)

Air Quality Applications

For More Information

General Overview
J. Al-Saadi et al, *Bulletin of the American Meteorological Society*, September 2005, 1249-1261



Satellite-Surface Correlations
J.A. Engel-Cox et al., *Atmospheric Environment* 38 (2004), 2495–2509

Three-Dimensional Perspectives
J. A. Engle-Cox et al., *Atmospheric Environment* 40 (2006), 8056-8067

May 2007 Air Quality and Public Health Workshop
http://weather.msfc.nasa.gov/conference/healthconference_home.html

Websites
http://idea.ssec.wisc.edu/ http://alg.umbd.edu/usaq

Environmental Public Health Tracking

Hazard

Exposure

Health Effect

Data

Ongoing Evaluation

COLLECTION → INTEGRATION → ANALYSIS → INTERPRETATION

Tracking Network

Dissemination

Assessment • Research • Intervention • Policy

Stakeholders*

Prevention

Improved Public Health

Ongoing Evaluation

*Stakeholders Include	
Federal Agencies	Business and Industry
State and Local Agencies	Policy Makers
Academia	Media
Health Care System	Public
Non-Governmental Organizations	

Department of Health and Human Services
Centers for Disease Control and Prevention
Safer • Healthier • People

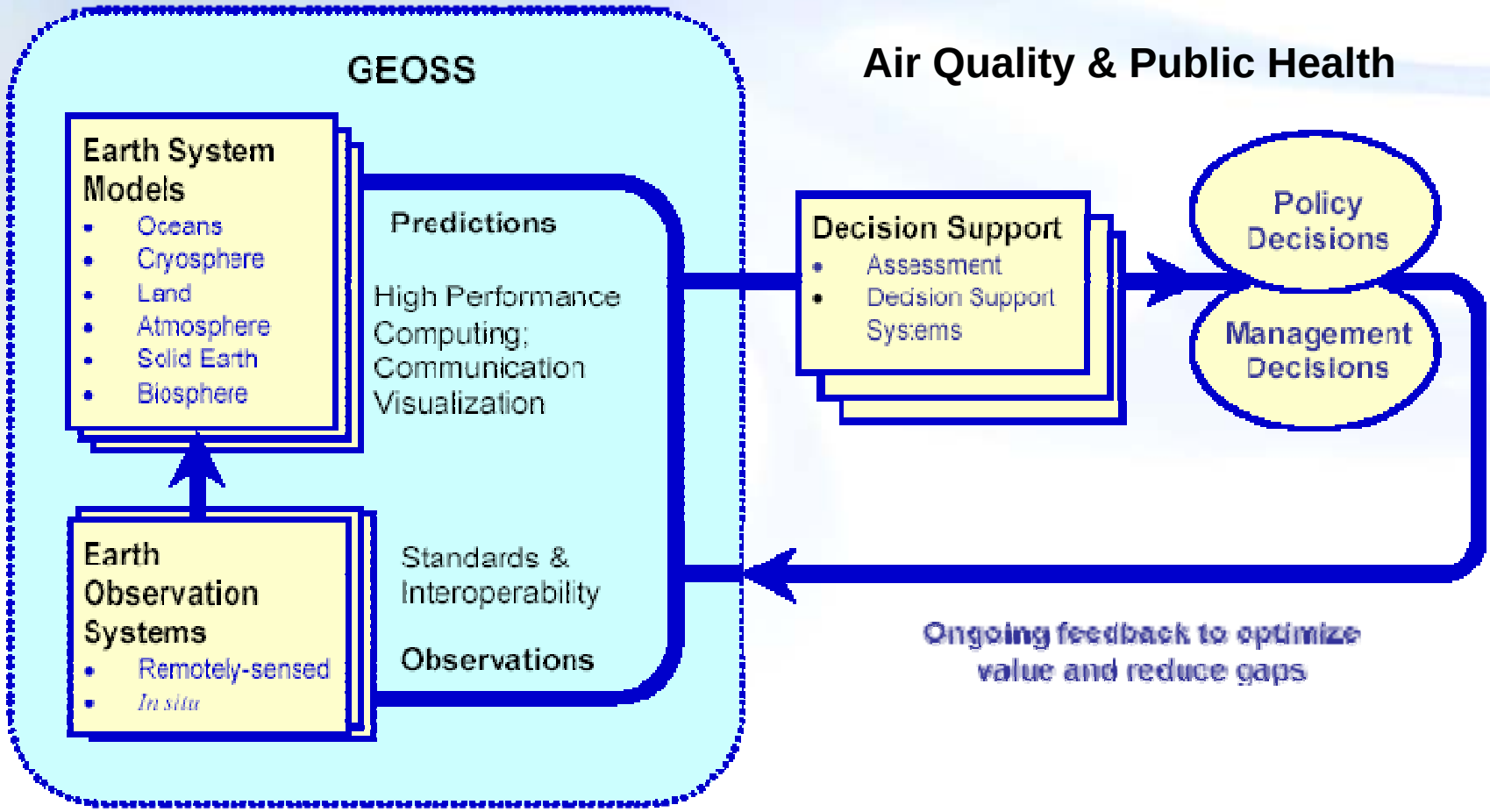
CDC
Safer • Healthier • People™

Air Quality Applications

Back-up

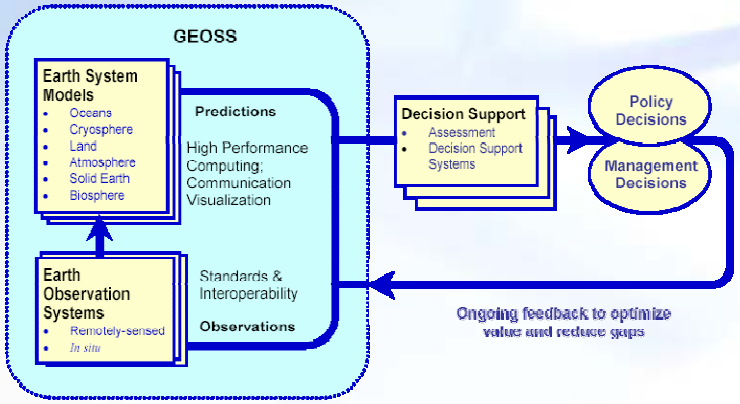
Earth Observations & Air Quality

Integrated Solutions & Decision Support



Earth Observations & Air Quality

Integrated Solutions & Decision Support



Management

- Forecasting – 3-D Air Quality
- Planning – Control Strategies
- Emissions Inventories
- Tracking
- Epidemiology (Action/Prevention)

Policy

- Rule-making
- Exceptional Events
- Accountability
- Long-range Transport / LRTAP
- Epidemiology (AQ Standards)

Air Quality Applications

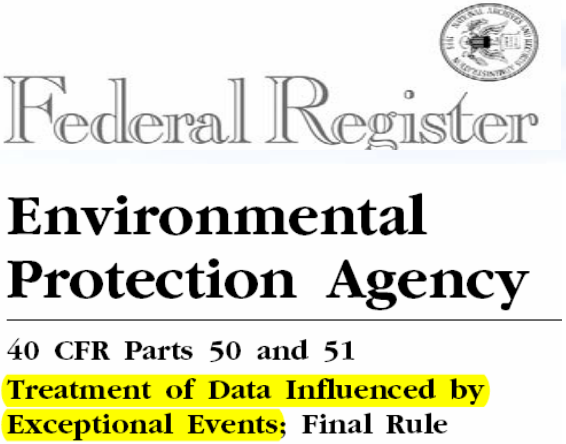
Recent Developments & Opportunities

<u>International</u>

- Long-range Transport
  - HTAP Study
  - LRTAP Convention
- Activities under USGEO & AQ NTO

<u>United States</u>

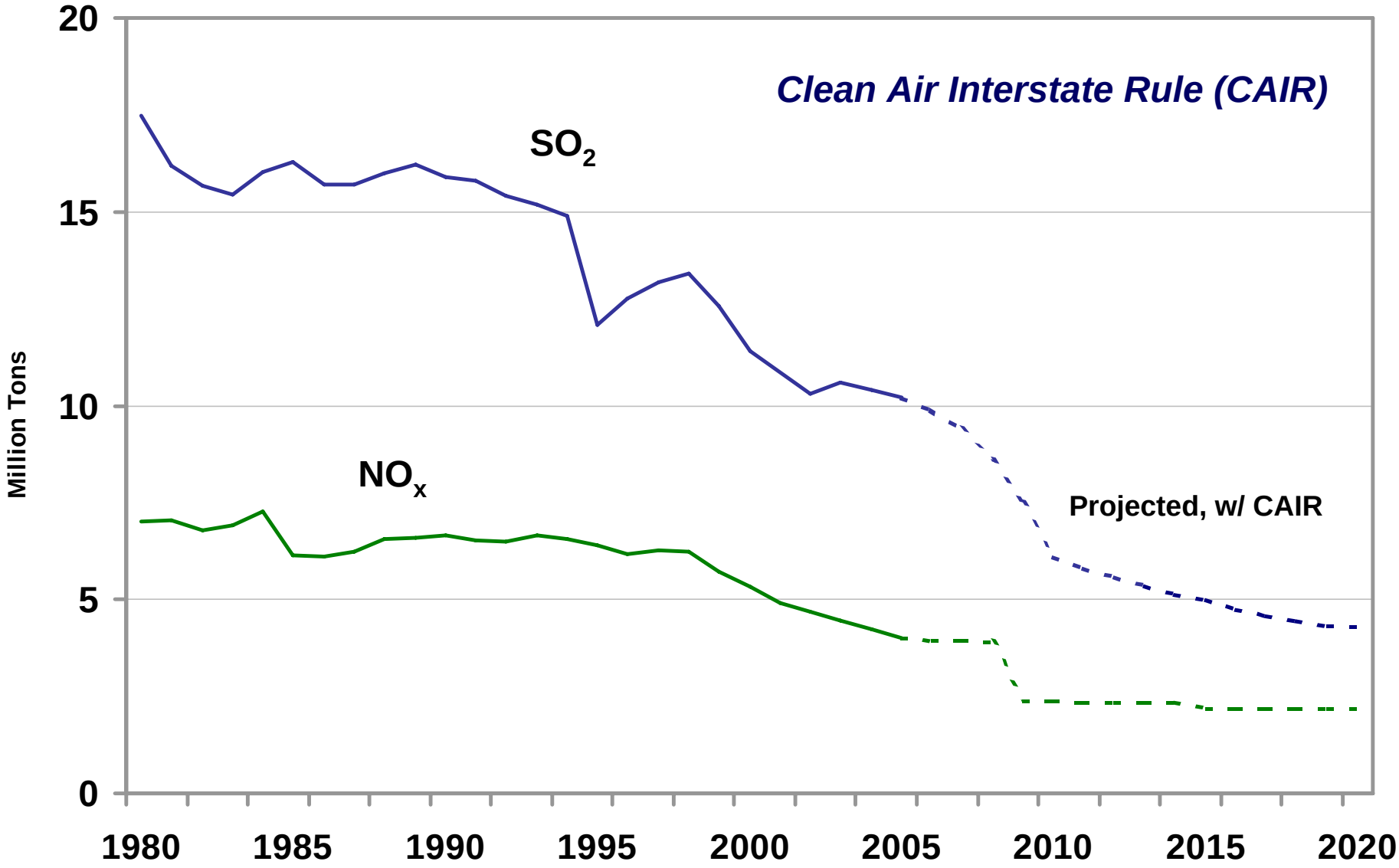
- NOAA national forecast guidance
  - Next-day Ozone by 2008, PM by 2012
  - Extend forecasts to 2^{+} days
  - Add additional pollutants
- Exceptional Events
- Clean Air Interstate Rule



Satellite evidence for Exceptional Event (smoke, dust) is now permissible

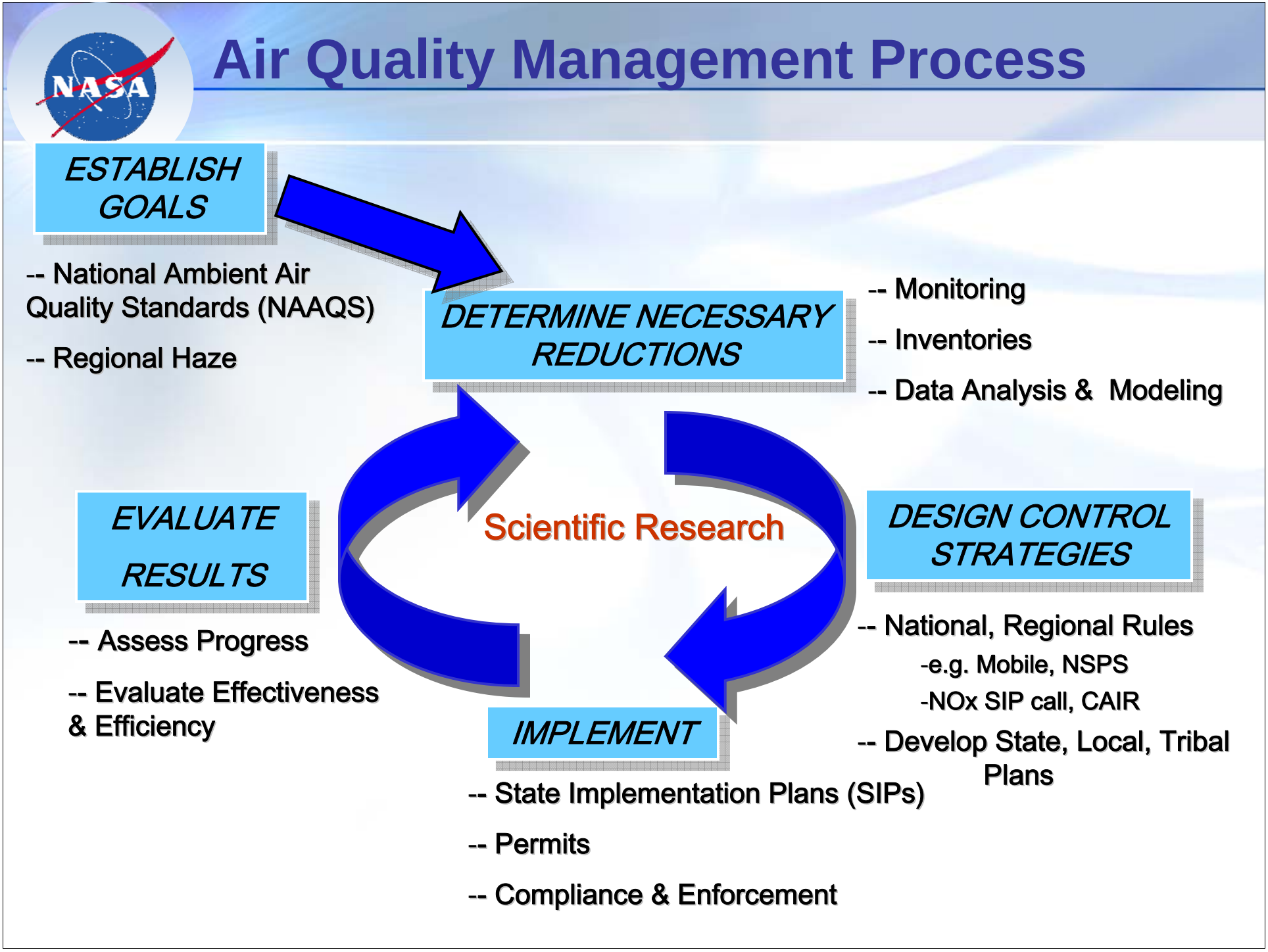
USA NO_x and SO_2 Power Plant Emissions

Historic and Projected with CAIR

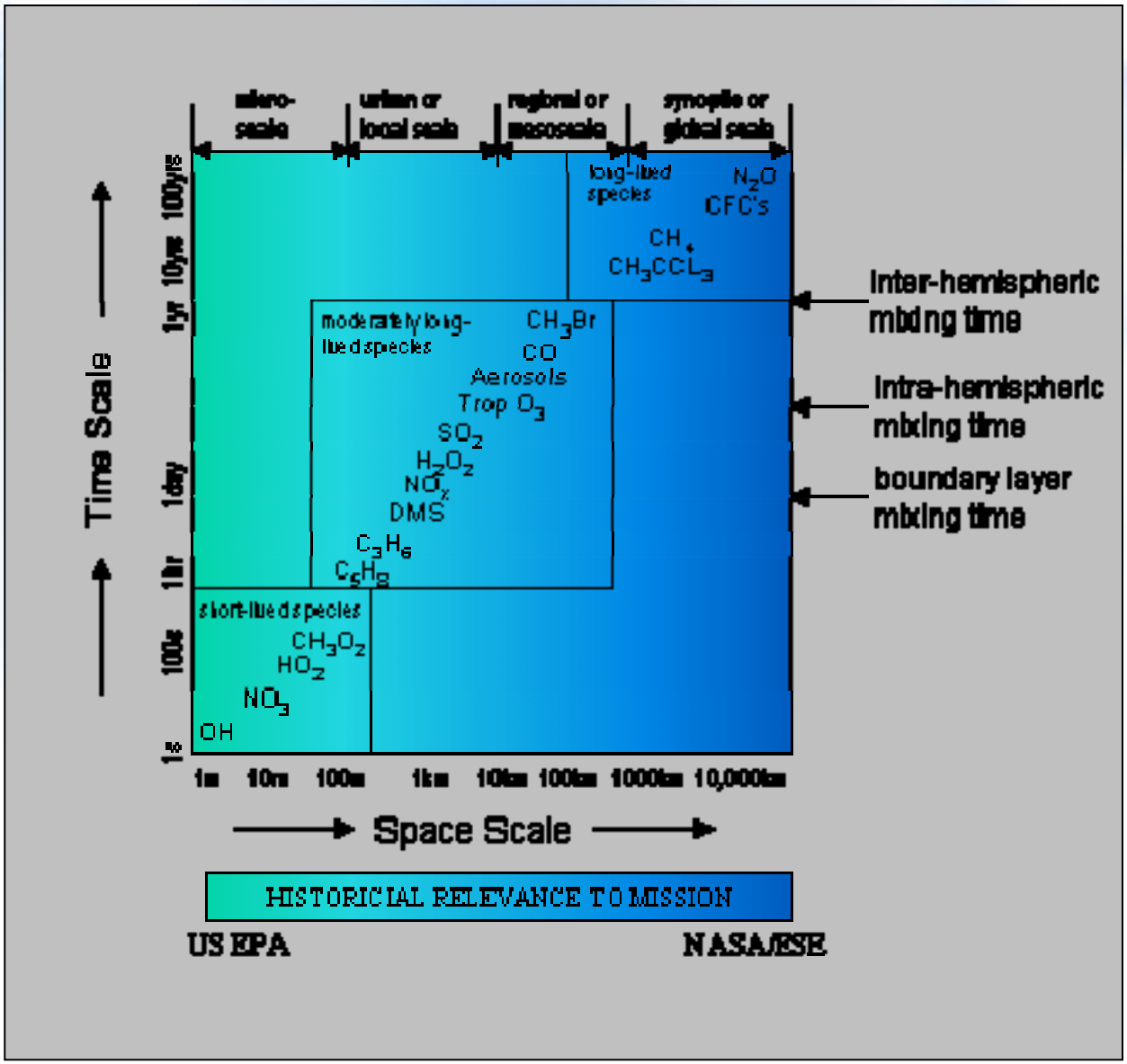


Source: EPA

Air Quality Management Process



Space in Operational & Research Agencies

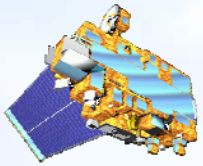


Intended application drives the focus of different agencies over spatial and temporal scales of atmospheric constituents.

Adapted from: National Academy of Sciences, 1998

Air Quality: IDEA Project

Data fusion to support EPA AirNOW & NOAA next-day fine particle air quality forecasting.



EPA/NOAA interest in PM 2.5: AQ Forecasting and Transport

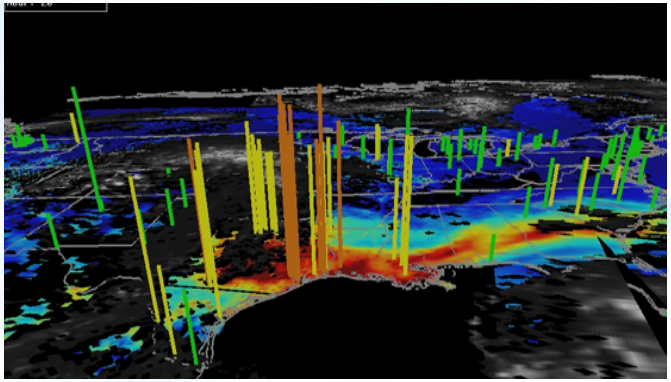
Comparisons of satellite observations data with EPA TEOM ground monitors
- Terra/Aqua MODIS Aerosol Optical Depth

Favorable comparisons, through methodology worked out by AQ team. Visual and statistical correlations.

Developed data fusion techniques to support visualizations of regional transport. Added additional data sets and modeling activities – aerosols, clouds, winds, fire locations, ground aerosols. Multiple day sequences of:

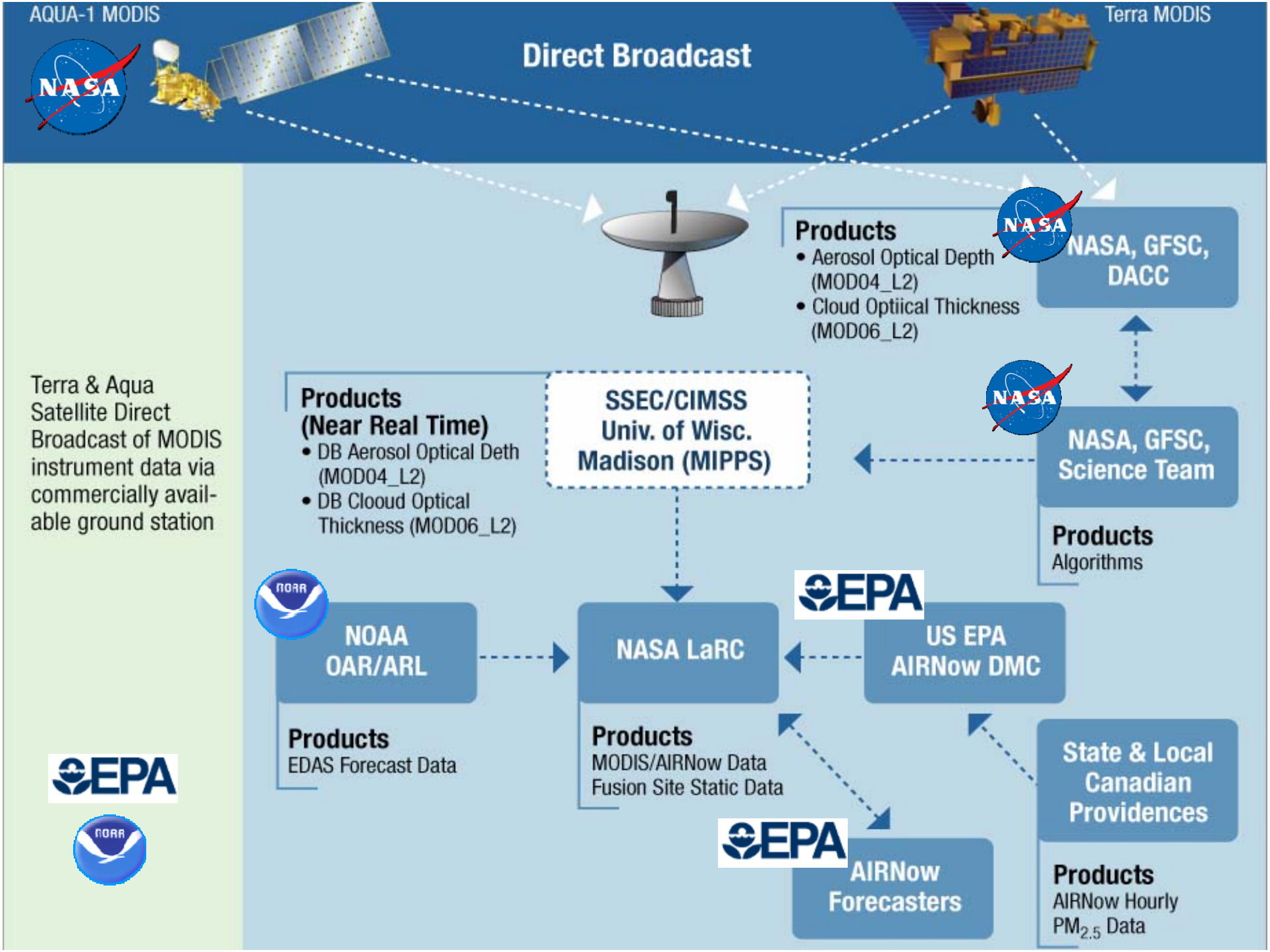
- MODIS AOD
- EPA TEOM
- NOAA EDAS winds
- MODIS COT
- NOAA WF-ABBA fire counts
- Air parcel trajectories

Provided "weight of evidence" supporting EPA transport rule-making.



Project Successes

- ***EPA conducted forecaster training on use of integrated data products***
- ***Demonstration to EPA AA for Air & Radiation***
- ***MODIS and project referenced in EPA's Clear Air Interstate Rule (Fed. Reg. Jan'05)***
- ***Cover story of BAMS (Sept. 2005)***
- ***Interagency, inter-Center project***
- ***Prompted independent follow-on projects to add CALIPSO for 3-D aspects***
- ***Benchmark report showed general support from forecasters for use of satellite products***
- ***Transition to EPA/NOAA payment of system operations at CIMSS (May 2004)***
- ***Transition to NOAA NESDIS operations***



New PM NAAQS 2006

- Annual NAAQS 15 ug/m3
- 24 hour 98th percentile NAAQS 35 µg/m3
  - From 65 µ g/m3
  - Implications ….new definition for anomalous events
    - Increased relevance of remote sensing information
- PM10 remains
- Requirements for $PM_{10-2.5}$ monitoring
  - focus on urban coarse PM resuspended by heavy traffic, industrial sources, and construction
    - excludes rural dust uncontaminated by urban, industrial sources (excludes agriculture, mining, wind blown dust